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THE POWER & SPEED OF STEAM VESSELS

WILLIAM BURY M.I.M.E

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THE

POWER AND SPEED

OF

STEAM VESSELS;

CALCULATED BY

RULES ADAPTED FOR VESSELS OF ALL TYPES.

BY

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INTRODUCTION.

THE writer having been for many years principally engaged in designing marine engines and superintending their construction, the subject of the resistance of vessels, or the amount of power required to drive a vessel at any given speed, had frequently to engage his attention.

As twenty or thirty years ago—with the exception of vessels for the navy or vessels for towing or other similar special purposes—most sea-going vessels were built in the proportion of 7 beams to the length, the resistance of vessels of this proportion might fairly be taken to be in proportion to the area of their midship section.

But about ten years ago many sea-going vessels were being built in the proportion of 8, 9, and even 10 beams to the length; and as vessels for the navy and other special purposes are built in the proportion of 6, 5, and even 4 beams to the length, the writer was desirous of ascertaining whether a set of tables, embodying the difference of the ratios in which vessels of all types may differ from a standard vessel, could not be constructed to facilitate the necessary calculations for ascertaining the amount of power required to drive a vessel of any type at any given speed, or the speed to be expected from a vessel of any type with any given amount of power.

Having fixed on the proportions of a standard vessel, the writer devoted a large amount of time in making the necessary

A sea-going vessel of the following proportions was selected as the vessel of a known type, or standard vessel, viz.:

O. M. tonnage 1000; length to beam = 7 times; draught = ½ beam. Fine lines. Displacement = 1·4 times O. M. tonnage; area of the midship section = 400 square feet; speed per hour = 8 knots. A vessel of this type, in ordinary sea-going in smooth water, was found to require $\frac{1}{3}$rd of an indicated horse-power per O. M. tonnage, or $\frac{5}{6}$ths of an indicated horse-power per square foot of area of midship section; the engines being ordinary condensing engines.

Selecting a vessel of a known type and ascertaining the power required in proportion to tonnage to drive her at a given speed per hour, and then comparing the proportions of other vessels with the same, with a view to determining the power required, is similar in principle to the practical method adopted of testing a bar of iron of given dimensions, to ascertain its strength, and then proportioning other bars according to the result obtained by the experiment.

The number of points in which vessels may vary are as follow:

1. O. M. tonnage.
2. Displacement to O. M. tonnage.
3. Length to beam.
4. Draught to beam.
5. Area of midship section.
6. Area of wet surface.
7. Speed per hour.

The power required will be in proportion to the multiple of the ratios of the different variations in the proportions of the

vessel which has to be compared, with the multiple of the ratios of the proportions of the vessel of a known type, or standard vessel.

The first step taken towards the construction of the Tables, was to work out the dimensions of the length and beam of vessels varying from 250 to 4000 tons O. M., and of 5, 7, 8, and 10 beams to the length as given in TABLES 1, 2, 3, 4. By means of these Tables the proportion of the cube contained in the length, beam, and draught, compared with the displacement, could be found; also the area of the midship section and the proportion of the wet surface for all these different vessels, which were afterwards available for working out the ratios given in the following Tables.

The variation in the proportion of displacement to O. M. tonnage was then considered, and it was found that no variation arises in this proportion, whether the O. M. tonnage be large or small; nor does it vary with any difference in the proportion of the length to beam; but arises solely in reference to the varying fullness of the lines, and the draught of water adopted for the vessel. The standard vessel being called a fine-line vessel, it was found that very fine-line vessels had $\frac{1}{5}$th less displacement and full-line vessels $\frac{1}{5}$th more displacement in proportion to O. M. tonnage: it was further found that vessels built for a light draught generally have fuller lines than those built for a greater draught, in the following proportion to the cube contained in the dimensions of the length, beam, and draught of water: viz. at draught = $\frac{1}{2}$ beam (the proportion of the standard vessel) the displacement = $\frac{1}{2}$ cube; at draught = $\frac{1}{4}$ beam, the displacement = $\frac{5}{8}$ cube; at draught = $\frac{1}{8}$ beam, the displacement = $\frac{3}{4}$ cube.

TABLE 5 has been prepared according to these proportions, and shows the proportion of displacement to O. M. tonnage for vessels of various fullness of lines at varying draughts of water.

Taking into consideration the difference in the form given to the body of vessels having different fullness of lines, it was found that the average rise of floor (which is the vertical height measured at the ship's side, of the incline given to the bottom of a vessel) at the midship section, was for full lines ·1 of draught of water, ·25 for fine lines, and ·4 for very fine lines; these variations give a difference of $\frac{1}{10}$th more area of midship section to vessels with full lines, and of $\frac{1}{10}$th less to vessels with very fine lines, when compared with a vessel having fine lines as given to the standard vessel. It will thus be evident that vessels with full lines will require $\frac{1}{10}$th more power, and vessels with very fine lines $\frac{1}{10}$th less power than a vessel with fine lines, owing to the variation in the respective areas of the midship section; but it has already been stated that the difference in the displacement of full line and very fine line vessels, when compared with a vessel having fine lines, amounts to $\frac{1}{5}$th more and $\frac{1}{5}$th less respectively, as shown in TABLE 5: consequently for the different fullness given to the fore and aft lines of vessels, a further variation occurs in the required power, amounting to $\frac{1}{10}$th more for vessels having full lines, and $\frac{1}{10}$th less for vessels having very fine lines.

TABLES 6 and 7 have been prepared according to these proportions.

TABLE 6 shows the proportion of indicated horse-power—for four various types of engines—required per O. M. tonnage with reference to the variation in the fullness of the fore and aft lines of the vessel, due to the difference in the displacement of

vessels having the various fullness of lines shown in the Table; the speed of vessel being 8 knots per hour.

TABLE 7 gives the ratio of the variation in the power required per O. M. tonnage with reference to the variation in the area of the midship section of vessels having the different proportions of length to beam shown in the Table, and of various fullness of lines.

The area of the midship section of a vessel is not only affected by the difference of displacement at a given draught, and by the difference in the proportion of the length to beam of vessel, but it is again affected by the increased proportion of displacement to O. M. tonnage generally given to vessels of a light draught, when compared with the standard vessel, as already explained for TABLE 5. The proportion of the displacement to the cube of the length, beam, and draught of a vessel, being taken at $\frac{1}{2}$ the cube for the standard vessel, in which the draught equals $\frac{1}{2}$ beam, at $\frac{5}{8}$ths of cube for vessels when draught equals $\frac{1}{4}$ beam, and at $\frac{3}{4}$ths of cube for vessels when draught equals $\frac{1}{8}$ beam, the proportions of the displacement to O. M. tonnage for vessels of 1000 tons O. M. and 7 beams to the length, were calculated at the above draughts, and at the other proportions of draught to beam given in TABLE 8; and from these proportions of displacement to O. M. tonnage the ratios given in the Table are derived, taking the proportion of the standard vessel as unity.

For vessels of other proportions of tonnage, and of length to beam, the proportions of displacement to O. M. tonnage at various draughts of water do not vary from those given in TABLE 8, consequently the ratios are the same.

In addition to the increased displacement in proportion to O. M. tonnage of vessels built for a light draught of water, there is the increased friction due to the increased proportion of wet surface, and the ratio of the increased wet surface has been found to amount to that given in TABLE 8; therefore the increase of power required per O. M. tonnage for variations in the proportions of displacement and wet surface of light-draught vessels is the product of these two ratios, and their product is given in the last column of TABLE 8.

As vessels are designed by different builders, and for various purposes, the rise of floor given to the midship section in proportion to the draught of water will vary; and this variation in the area of the midship section, although the displacement remains the same, will produce a difference in the ratio of power required per area of midship section in proportion to the displacement: therefore, to allow for this variation it is necessary to compute the power required per O. M. tonnage, and again per area of midship section, and take the mean of the two quantities thus found, as the power that will be required. For of two vessels having the same displacement at the same draught, and being of the same O. M. tonnage, the vessel that has the greatest area of midship section will require the greatest amount of power.

TABLE 9 shows the proportion of indicated horse-power—for four various types of engines—required per area of midship section with reference to the variation in the fullness of the fore and aft lines of the vessel, due to the difference in the displacement of vessels having the various fullness of lines shown in the Table: the speed of vessel being 8 knots per hour.

To enable the relative proportions of the area of midship

section of vessels built for a light draught in proportion to the increased displacement, to be compared with the standard vessel having the draught = ½ beam, the proportions of the area of the midship section per O. M. tonnage for the various draughts given in TABLE 10 were worked out; and having already found the proportion of displacement per O. M. tonnage, given in TABLE 8, by dividing the latter quantity by the former, the proportion of the displacement to the area of the midship section is obtained, and from these proportions the ratios given in TABLE 10 were derived, taking as unity the proportion when draught = ½ beam, which is that of the standard vessel.

But in addition to the increased displacement in proportion to the area of midship section of vessels built for a light draught of water, there is again the increased friction due to the increased proportion of the wet surface, and the ratio of the increased wet surface due to the increased displacement is the same as that given in TABLE 8; therefore the increase of power required for area of midship section, for the variations in the proportions of displacement and wet surface of light-draught vessels, is the product of these two ratios, and their product is given in the last column of TABLE 10.

The proportions of the wet surface for vessels of different tonnage and of different proportions of length to beam had then to be compared with the wet surface of the standard vessel, and in doing this it was assumed that the wet surface of the standard vessel would be in proportion to the length multiplied by (½ the beam and by twice the draught of water).

It is desirable here to point out that if this assumption be not quite correct, that as the power required is in proportion to

the ratios of the different vessels compared with the ratio of the standard vessel, and that the proportions for all vessels are computed on the same plan, it follows that the ratios would remain the same although the proportions might be different; therefore no inaccuracy will occur by taking the above proportions.

The proportions of the wet surface for vessels of different tonnage and of different proportions of length to beam, but all having the draught equal to half the beam (which is that of the standard vessel), have then been computed according to the above assumption, and are given in TABLES 11 and 12, and from these proportions the ratios are derived, taking the proportion of the standard vessel as unity.

For the variation in speed per hour, it is only necessary to remember that the power required varies as the cube of the speed required; therefore taking the ratio of the speed of the standard vessel, or 8 knots per hour, as unity, the ratios of other speeds are found by dividing the cube of the speed required in knots per hour by the cube of 8, or 512. TABLE 13 has thus been prepared.

NOTE.—In calculating the power required per area of midship section, it is not necessary to allow anything for the variation in the proportion of length to beam, for the area of the midship section is directly affected in proportion to the ratios given in TABLE 7, nor is it necessary to allow anything for the variation in the proportion of wet surface per O. M. tonnage; for it will be seen by TABLE 11 that although the proportions of the wet surface and of the areas of midship section, per O. M. tonnage vary, their ratios are the same: this shows that the area of midship section is directly affected in the same ratio as

the wet surface per O. M. tonnage, consequently no further allowance for this variation is required.

All the Tables have now been explained; and three diagrams have been prepared from TABLES 5, 8, and 10, having a vertical and horizontal scale, by means of which the proportions or ratios required for vessels of any intermediate proportions to those given in the Tables can be readily found; the vertical lines at the given draught of the vessel, from the base to the curve line, will be the proportion or ratio required in all cases. The diagrams will be found after the Tables.

Before proceeding to the application of these Tables, it will be convenient to give the following summary of them :—

TABLES 1, 2, 3, 4, give the dimensions of vessels of different O. M. tonnage, and of various proportions of length to beam.

TABLE 5 gives the proportion of displacement to O. M. tonnage, for vessels of various draughts of water and of various fullness of lines.

TABLE 6 gives the proportion of indicated horse-power—for four various types of engines—required per O. M. tonnage, at various fullness of lines due to variations in the fore and aft lines of vessel, to suit displacement; the speed of vessel being 8 knots per hour.

TABLE 7 gives the ratio of power required per O. M. tonnage for vessels of different proportions of length to beam at various fullness of lines, due to the variation in the area of midship section.

TABLE 8 gives the ratio of power required per O. M. tonnage for vessels of various draughts of water, due to the variations of displacement and wet surface.

TABLE 9 gives the proportion of indicated horse-power—for four various types of engines—required per area of midship section at various fullness of lines, due to variations in the fore and aft lines of vessel to suit displacement: the speed of vessel being 8 knots per hour.

TABLE 10 gives the ratio of power required per area of midship section for vessels of various draughts, due to the variations of displacement and wet surface.

TABLE 11 gives the ratio of power required for vessels of different O. M. tonnage, due to variation of wet surface; it also shows the ratio of variation in the area of midship section, for vessels of different O. M. tonnage.

TABLE 12 gives the ratio of power required for vessels of different proportions of length to beam, due to variation in the wet surface.

TABLE 13 gives the ratio of power required for vessels of different speeds per hour.

RULES FOR POWER REQUIRED BY VESSELS.

To apply the following Tables to the calculation of the power required to drive any vessel at any speed per hour, it is necessary to have the following particulars of the vessel, viz.:—Length, beam, draught, displacement at that draught, area of midship section, and speed required in knots per hour: then proceed as follows:—

Find the O. M. tonnage of the vessel by the following rule: From the length deduct $\frac{3}{5}$ths of the beam, and multiply the remainder by the beam and again by half the beam, and divide the product by 94. The quotient will be the O. M. tonnage.

Find the proportion of displacement to O. M. tonnage by dividing the displacement by the O. M. tonnage; then find the proportion of draught to beam by dividing the draught by the beam. With these two proportions refer to TABLE 5, and decide thereby on the comparative fullness of the lines of the vessel.

Find the proportion of length to beam by dividing the length by the beam.

The following calculations will then have to be made; but the Note given hereafter should be first referred to.

1. To ascertain the indicated horse-power required per O. M. tonnage:

Multiply the O. M. tonnage by the number in TABLE 6 according to the type of engines and the fullness of lines, again by the number in TABLE 7 according to the fullness of lines and the proportion of length to beam, again by the number in the last column of TABLE 8 according to the draught of water, again by the number in TABLE 11 according to O. M. tonnage for wet surface, again by the number in TABLE 12 according to the proportion of length to beam for wet surface, and again by the number in TABLE 13 according to the speed per hour. The result will be the indicated horse-power required per O. M. tonnage.

2. To ascertain the indicated horse-power required per area of midship section:

Multiply the area of midship section in square feet by the number in TABLE 9 according to the type of engines and the fullness of lines, again by the number in the last column of TABLE 10 according to the draught of water, again by the number in TABLE 12 according to the proportion of length to beam for wet surface, and again by the number in TABLE 13

according to the speed per hour. The result will be the indicated horse-power required per area of midship section.

3. Should the results obtained by calculations 1 and 2 not be equal, the mean of the two quantities thus found will be the indicated horse-power that will be required for the vessel, for the reasons already explained.

NOTE.—It is essential to remember that the actual multipliers to be used in the foregoing Rules can only be taken from the Tables when the proportions of the vessel under consideration agree with those given in the Tables. For vessels of other or intermediate proportions, it must be borne in mind—that as TABLE 5 has only been prepared for the proportions of displacement to O. M. tonnage, at the draughts of water and at the various fullness of lines given therein, sufficient to enable the diagram from TABLE 5 to be prepared—therefore, to determine accurately, for all intermediate proportions, the comparative fullness of lines and the consequent proportion of indicated horse-power required per O. M. tonnage to be derived from TABLE 6, and the consequent ratio of power to be derived from TABLE 7, also the consequent proportion of indicated horse-power required per area of midship section to be derived from TABLE 9, it is desirable in all cases to draw a vertical line on the diagram from TABLE 5, from the base line, at the exact draught of water of the vessel under consideration,—this vertical line to be equal in length, at the scale given for the diagram, to the proportion of the displacement to O. M. tonnage found for the vessel under consideration. If the vertical line, at the draught of water, if given in the Table, is bounded by one of the curves of the

diagram, the corresponding numbers for the fullness of lines thus found can be taken from the TABLES 6, 7, and 9. If, however, this vertical line ends between two of the curve lines of the diagram, it will at once be seen that a proportional alteration must be made in the numbers to be derived from the TABLES 6, 7, and 9. For vessels with draught of water intermediate to those given in TABLE 5, the same method must be adopted, and the proportional numbers to be derived from TABLES 6, 7, and 9, will be arrived at in the same manner. A further proportional alteration will be required in the ratios of TABLE 7, for vessels having a different proportion of length to beam to those given in the Table.

It is likewise essential to remember that for vessels of intermediate draught of water to those given in TABLES 8 and 10, the ratios of the power required should be measured from the diagrams prepared from these Tables respectively.

For the same reasons ratios must be taken, intermediate to those given in TABLES 11, 12, and 13, for vessels having different proportions of tonnage, length to beam, and speed per hour, to those given in these Tables.

A few examples have been added to show the application of the Tables, and to enable the indicated horse-power obtained by the calculations to be compared with the indicated horse-power obtained from practice.

In conclusion, these calculations are intended to apply to vessels when running with the bottom of the vessel fairly clean, and when the water is fairly smooth.

DIMENSIONS OF VESSELS.

Table 1. Length = 5 Beams.

O. M. Tonnage.	Length.		Beam.	
	Ft.	In.	Ft.	In.
250	110	0	22	0
500	138	6	27	9
750	158	9	31	9
1000	175	0	35	0
1500	200	0	40	0
2000	220	0	44	0
2500	237	6	47	6
3000	252	0	50	6
3500	265	6	53	1
4000	278	0	55	6

Table 2. Length = 7 Beams.

O. M. Tonnage.	Length.		Beam.	
	Ft.	In.	Ft.	In.
250	136	0	19	5¼
500	171	6	24	6
750	196	0	28	0
1000	216	0	30	10¼
1500	247	6	35	4
2000	272	0	38	10½
2500	293	0	41	10½
3000	311	6	44	6
3500	328	0	46	10
4000	343	0	49	0

Table 3. Length = 8 Beams.

O. M. Tonnage.	Length.		Beam.	
	Ft.	In.	Ft.	In.
250	149	0	18	6
500	187	0	23	4½
750	214	0	26	9
1000	235	0	29	6
1500	269	0	33	7½
2000	296	0	37	0
2500	319	0	39	10½
3000	339	0	42	4½
3500	357	0	44	7½
4000	373	0	46	8

Table 4. Length = 10 Beams.

O. M. Tonnage.	Length.		Beam.	
	Ft.	In.	Ft.	In.
250	171	0	17	1½
500	215	6	21	6½
750	246	6	24	8
1000	272	0	27	2
1500	311	0	31	1
2000	342	6	34	2
2500	368	0	36	10
3000	392	0	39	2
3500	412	0	41	3
4000	431	0	43	1

TABLES FOR POWER AND SPEED OF STEAM VESSELS.

TABLE 5. Proportion of Displacement to O. M. Tonnage, to decide on the comparative fullness of the lines of different vessels.

Draught to Beam.	Very fine lines.	Medium fine lines.	Fine lines.	Medium full lines.	Full lines.	Very full lines.
·6	1·28	1·44	1·6	1·76	1·92	2·08
·55	1·2	1·35	1·5	1·65	1·8	1·95
·5	1·11	1·25	1·39	1·53	1·66	1·8
·45	1·05	1·18	1·31	1·44	1·57	1·7
·4	·95	1·07	1·19	1·31	1·43	1·55
·375	·92	1·03	1·15	1·26	1·38	1·49
·33	·82	·92	1·02	1·12	1·22	1·32
·3	·76	·86	·96	1·05	1·15	1·24
·25	·67	·75	·84	·92	1·	1·09
·2	·55	·62	·69	·76	·82	·9
·166	·48	·54	·6	·66	·72	·78
·125	·37	·41	·46	·5	·55	·6

TABLE 6. Proportion of Indicated Horse-power required per O. M. Tonnage, according to the Displacement of the Vessel, in relation to the fore and aft lines. The Speed of Vessel being 8 knots per hour.

Type of Engines.	Very fine lines.	Medium fine lines.	Fine lines.	Medium full lines.	Full lines.	Very full lines.
Ordinary Condensing	·3	·315	·33	·345	·36	·375
Compound	·254	·268	·282	·296	·31	·324
Compound, with separate Circulating	·238	·251	·264	·277	·29	·303
Ordinary Non-condensing ..	·223	·235	·247	·259	·271	·283

TABLES FOR POWER AND SPEED OF STEAM VESSELS—*continued.*

TABLE 7. Ratio of the Indicated Horse-power required per O. M. Tonnage, according to the Displacement of the Vessel, in relation to the Area of Midship Section.

Length to Beam.	Very fine lines.	Medium fine lines.	Fine lines.	Medium full lines.	Full lines.	Very full lines.
10 times	·716	·756	·796	·835	·875	·914
9 „	·754	·807	·86	·903	·946	·989
8 „	·832	·878	·924	·97	1·016	1·062
7 „	·9	·95	1·	1·05	1·1	1·15
6½ „	·946	·998	1·04	1·092	1·144	1·196
6 „	·99	1·045	1·1	1·155	1·210	1·265
5½ „	1·036	1·093	1·15	1·207	1·264	1·321
5 „	1·111	1·172	1·233	1·294	1·355	1·416
4½ „	1·188	1·254	1·32	1·386	1·452	1·518
4 „	1·306	1·378	1·45	1·522	1·594	1·666

TABLE 8. Ratio of the Indicated Horse-power required per O. M. Tonnage, in relation to the difference of Draught of Water.

Draught to Beam.	Displacement to Cube.	Proportion of Displacement to O. M.	Ratio of Displacement to O. M.	Ratio of Wet Surface.	Ratio of power required per O. M.
·6	·475	1·6	1·15	·98	1·127
·55	·487	1·5	1·08	·99	1·07
·5	·5	1·39	1·	1·	1·
·45	·525	1·31	·935	1·018	·951
·4	·54	1·19	·856	1·039	·889
·375	·55	1·15	·827	1·05	·868
·33	·562	1·02	·732	1·07	·783
·3	·587	·96	·69	1·1	·759
·25	·625	·84	·6	1·125	·675
·2	·66	·69	·5	1·183	·591
·166	·7	·6	·411	1·237	·533
·125	·75	·46	·33	1·3	·429

TABLES FOR POWER AND SPEED OF STEAM VESSELS—*continued.*

TABLE 9. Proportion of Indicated Horse-power required per square foot of Area of the Midship Section of the Vessel, in relation to the fore and aft lines. The Speed of Vessel being 8 knots per hour.

Type of Engines.	Very fine lines.	Medium fine lines.	Fine lines.	Medium full lines.	Full lines.	Very full lines.
Ordinary Condensing	·75	·791	·833	·875	·916	·957
Compound	·643	·678	·713	·748	·783	·818
Compound, with separate Circulating	·6	·633	·666	·7	·733	·766
Ordinary Non-condensing ..	·562	·593	·624	·655	·686	·717

TABLE 10. Ratio of the Indicated Horse-power required per Area of the Midship Section of Vessel, in relation to the difference of Draught of Water.

Draught to Beam.	A. M. S. to O. M.	Displacement to O. M.	Displacement to A. M. S.	Ratio of displacement to A. M. S.	Ratio of Wet Surface.	Ratio of power required per A. M. S.
·6	·478	1·6	3·35	·93	·98	·91
·55	·431	1·5	3·48	·97	·99	·96
·5	·388	1·39	3·58	1·	1·	1·
·45	·346	1·31	3·8	1·06	1·018	1·079
·4	·305	1·19	3·92	1·09	1·039	1·132
·375	·285	1·15	4·	1·11	1·05	1·165
·33	·25	1·02	4·1	1·14	1·07	1·219
·3	·22	·96	4·33	1·21	1·1	1·331
·25	·18	·84	4·6	1·28	1·125	1·44
·2	·14	·69	4·88	1·363	1·183	1·612
·166	·116	·6	5·18	1·446	1·237	1·788
·125	·082	·46	5·62	1·57	1·3	2·04

TABLES FOR POWER AND SPEED OF STEAM VESSELS—*continued.*

TABLE 11. Proportion and Ratio of A. M. S. and Wet Surface of Vessels in relation to difference of O. M. Tonnage.

O. M. Tonnage of Vessel.	Area of Midship Section.		Wet Surface.	
	Proportion.	Ratio.	Proportion.	Ratio.
250	·61	1·56	15·84	1·58
500	·49	1·255	12·6	1·26
750	·424	1·08	11·	1·1
1000	·39	1·	10·	1·
1500	·343	·88	8·74	·874
2000	·312	·795	7·92	·792
2500	·288	·738	7·35	·735
3000	·273	·696	6·93	·693
3500	·258	·66	6·58	·658
4000	·248	·632	6·3	·63
4500	·238	·61	6·	·6
5000	·23	·59	5·84	·584
5500	·222	·57	5·69	·569
6000	·217	·555	5·5	·55

TABLE 12. Ratio of Wet Surface of Vessel, in relation to difference of length to beam.

Length to Beam.	Ratio of Wet Surface.
10 times	1·108
9 „	1·074
8 „	1·041
7 „	1·
6½ „	·981
6 „	·96
5½ „	·94
5 „	·92
4½ „	·895
4 „	·87
3½ „	·85
3 „	·82

TABLE 13. Ratio of the power required for different speeds per hour.

Knots per hour.	Ratio of Power.
7	·67
7½	·823
8	1·
9	1·42
10	1·93
11	2·6
12	3·37
13	4·29
14	5·35
15	6·6
16	8·
17	9·6
18	11·39

SS. "MAHROUSSÉE"—PADDLE.

Type of Engines—Ordinary Condensing.

Length of Vessel, 360 feet. Beam, 42 feet. Draught, 15 feet. A. M. S. = 500.

Displacement, 3135 tons. Speed per hour, 18½ knots. Ind. H. P. = 6400.

Displacement to O. M. Tonnage = 1. Draft to Beam = ·35. Length to beam = 8·5.

O. M. Tonnage = 3140		Area of Midship Section .. } = 500	Sq. feet.
·315	Lines.	·791	Lines.
989·1		395·5	
·84	L. to B.	1·19	Draught.
830·76		470·05	
·82	Draught.	1·06	W. S. length.
680·60		498·20	
·69	W. S. tonnage.	12·36	= 18½ knots.
469·20		6155·28	Ind. H. P.
1·06	W. S. length.		
497·14			
12·36	18½ knots.		
6142·92	Ind. H. P.		

Ind. H. P.

6142 O. M.
6155 A. M. S.

2)12297

6149· Mean Ind. H. P.

SS. "MARLBOROUGH"—Screw.

Type of Engines—Ordinary Condensing.

Length of Vessel, 245 feet. Beam, 61 feet. Draught, 26 feet 3 inches. A. M. S. = 1195.

Displacement, 6065 tons. Speed per hour, 11¼ knots. Ind. H. P. = 3022.

Displacement to O. M. Tonnage = 1·47. Draft to Beam = ·43. Length to Beam = 4.

O. M. Tonnage = 4125
·35 Lines.

1443·75
1·558 L. to B.

2248·194
·925 Draft.

2079·4
·635 W. S. tonnage.

1320·165
·87 W. S. length.

1148·4
2·78 = 11¼ knots.

3191·44 Ind. H. P.

Area of Midship Section .. = 1195 Sq. feet.
·895 Lines.

1069·525
1·1 Draft.

1175·9
·87 W. S. length.

1022·25
2·78 = 11¼ knots.

2841·16 Ind. H. P.

Ind. H. P.

3191 O. M.
2841 A. M. S.

2) 6032

3016· Mean Ind. H. P.

SS. "VANGUARD"—Screw.

Type of Engines—Compound.

Length of Vessel, 230 feet. Beam, 30 feet. Draught, 15 feet 6 inches. A. M. S. = 420.

Displacement, 1889 tons. Speed per hour, 7¾ knots. Ind. H. P. = 330

Displacement to O. M. Tonnage = 1·85. Draft to Beam = ·516. Length to Beam = 7·66.

O. M. Tonnage = 1015
·324 Lines.

328·86
1·11 L. to B.

364·08
1·01 Draught.

367·64
1· W. S. tonnage.

367·
1·02 W. S. length.

374·
·908 = 7¾ knots.

339·792

Area of Midship Section .. = 420 Sq. feet.
·818 Lines.

343·56
·99 Draught.

339·57
1·02 W. S. length.

345·78
·908 = 7¾ knots.

312·26 Ind. H. P.

Ind. H. P.

339 O. M.
312 A. M. S.

2) 651

325 Mean Ind. H. P.

SS. "HELEN"—Screw Yacht.

Type of Engines—Compound.

Length of Vessel, 156 feet 9 inches. Beam, 20 feet 6 inches. Draught, 9 feet 6 inches. A. M. S. = 108.

Displacement, 335 tons. Speed per hour, 11 knots. Ind. H P. = 248.

Displacement to O. M. Tonnage = 1·04. Draught to Beam = ·45. Length to Beam = 7·64.

O. M. Tonnage = 322
·254 Lines.

81·788
·87 L. to B.

70·47
·95 Draught.

66·50
1·46 W. S. tonnage.

96·36
1·02 W. S. length.

97·92
2·6 = 11 knots.

252·2 Ind. H. P.

Area of Midship Section .. } = 108 Sq. feet.
·643 Lines.

69·444
1·08 Draught.

74·52
1·02 W. S. length.

75·48
2·6 = 11 knots.

195·0 Ind. H. P.

Ind. H. P.
252 O. M.
195 A. M. S.

2) 447

224 Mean Ind. H. P.

S.S. "BRITANNIC"—Screw.

Type of Engines—Compound, with separate Circulating Engines.

Length of Vessel, 455 feet. Beam, 45 feet 2 inches. Draught, 23 feet 7 inches. A. M. S. = 926 feet.

Displacement, 8500 tons. Speed per hour, 15 knots. Ind. H. P. = 4900.

Displacement to O. M. Tonnage = 1·84. Draught to Beam = ·522. Length to Beam = 10·.

O. M. Tonnage = 4610
·295 Lines.

1359·95
·894 L. to B.

1214·946
1·02 Draught.

1238·28
·6 W. S. tonnage.

742·8
1·108 W. S. length.

822·136
6·6 = 15 knots.

5425·2 Ind. H. P.

Area of Midship Section .. } = 926 Sq. ft.
·75 Lines.

694·5
·98 Draught.

680·12
1·108 W. S. length.

753·44
6·6 = 15 knots.

4969·8 Ind. H. P.

Ind. H. P.

5425 O. M.
4969 A. M. S.

2)10394

5197 Mean Ind. H. P.

SS. "ADMIRAL"—PADDLE.

Type of Engines—Ordinary Condensing.

Length of Vessel, 210 feet. Beam, 32 feet. Draught, 7 feet 6 inches. A. M. S. = 214.

Displacement, 820 tons. Speed per hour = $11\frac{3}{4}$ knots. Ind. H. P. = 744.

Displacement to O. M. Tonnage = ·82. Draught to Beam = ·23. Length to Beam = 6·5.

O. M. Tonnage =	1040	Area of Midship Section .. } =	214 Sq. ft.
	·33 Lines.		·83 Lines.
	347·		177·62
	1·04 L. to B.		1·51 Draught.
	360·88		267·27
	·635 Draught.		·98 W. S. length.
	228·6		261·66
	1· W. S. tonnage.		3·16 = $11\frac{3}{4}$ knots.
	228·		824·76 Ind. H. P.
	·98 W. S. length.		
	223·4		
	3·16 = $11\frac{3}{4}$ knots.		
	704·68 Ind. H. P.		

Ind. H. P.	
704·	O. M.
824·	A. M. S.
2)1528	
764·	Mean Ind. H. P.

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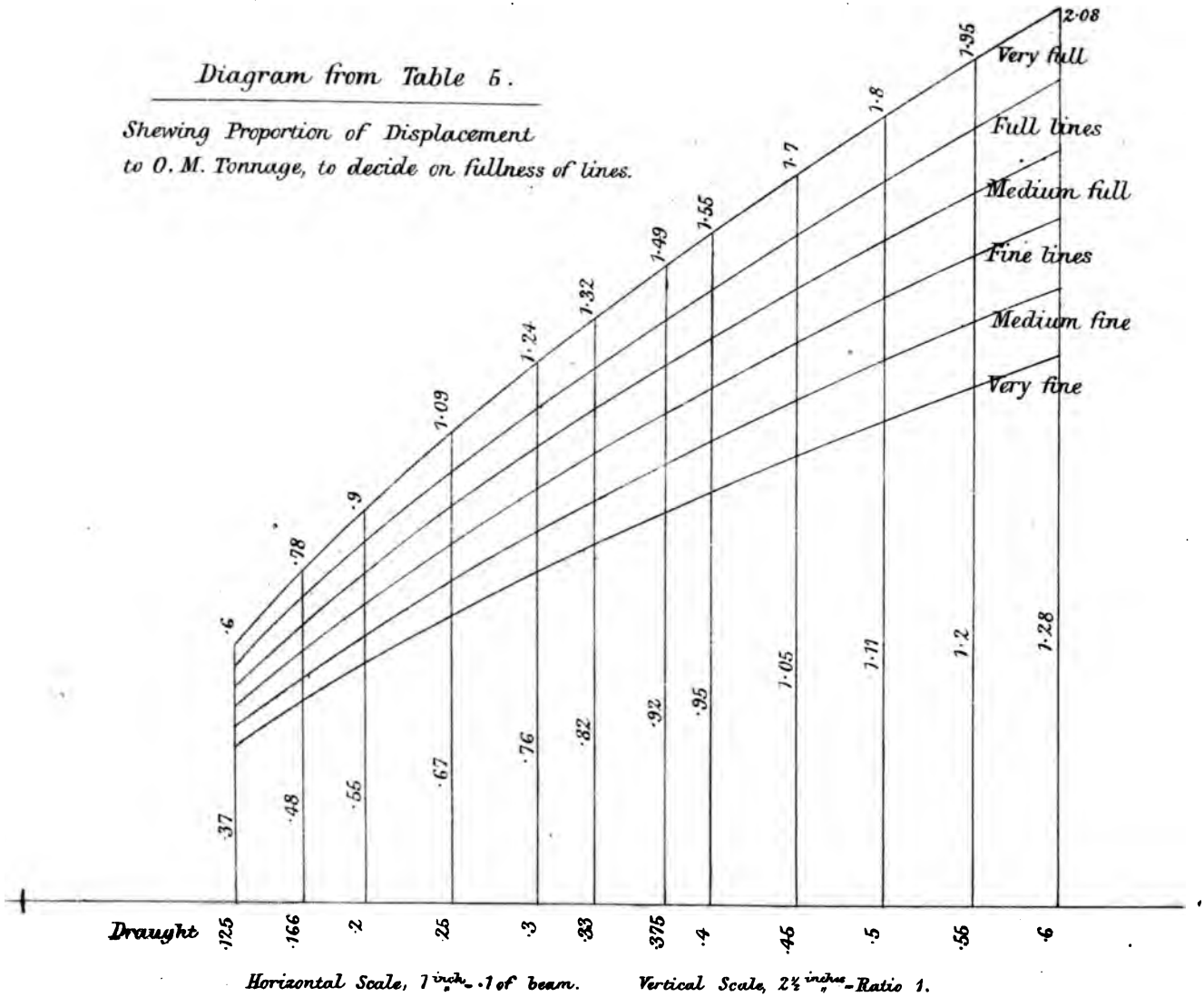


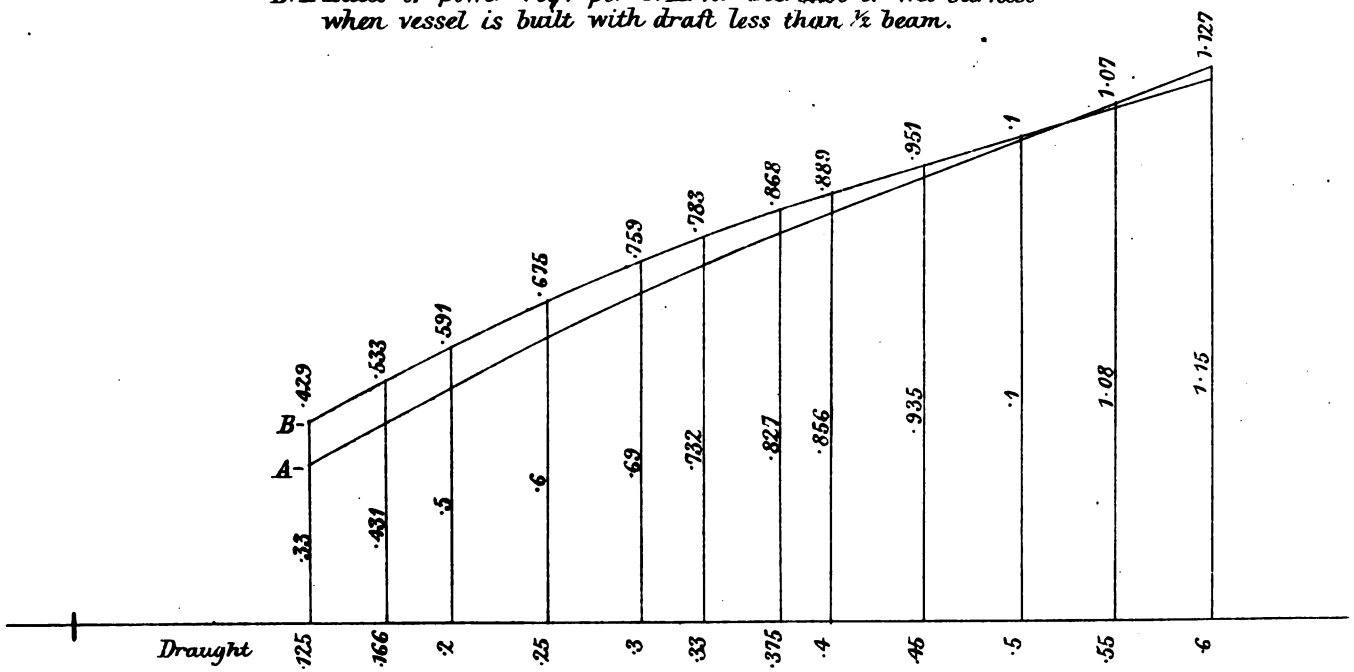
Diagram from Table 5.
Shewing Proportion of Displacement to O. M. Tonnage, to decide on fullness of lines.
Very full
Full lines
Medium full
Fine lines
Medium fine
Very fine
Draught
.125
.166
.2
.25
.3
.33
.375
.4
.45
.5
.55
.6
.6
.78
.9
1.09
1.24
1.32
1.49
1.55
1.7
1.8
1.95
2.08
.37
.48
.55
.67
.76
.82
.92
.95
1.05
1.11
1.2
1.28
Horizontal Scale, 1 inch = .1 of beam.
Vertical Scale, 2½ inches = Ratio 1.

Diagram from Table 8.

Shewing Ratio of displacement to O.M. Tonnage at different draughts of water.

A. — *Ratio of displacement to O.M.*

B. — *Ratio of power req.d per O.M. for increase of wet surface when vessel is built with draft less than ½ beam.*



Horizontal Scale, 1 inch = 1 of beam. *Vertical Scale, 2½ inches = Ratio 1.*

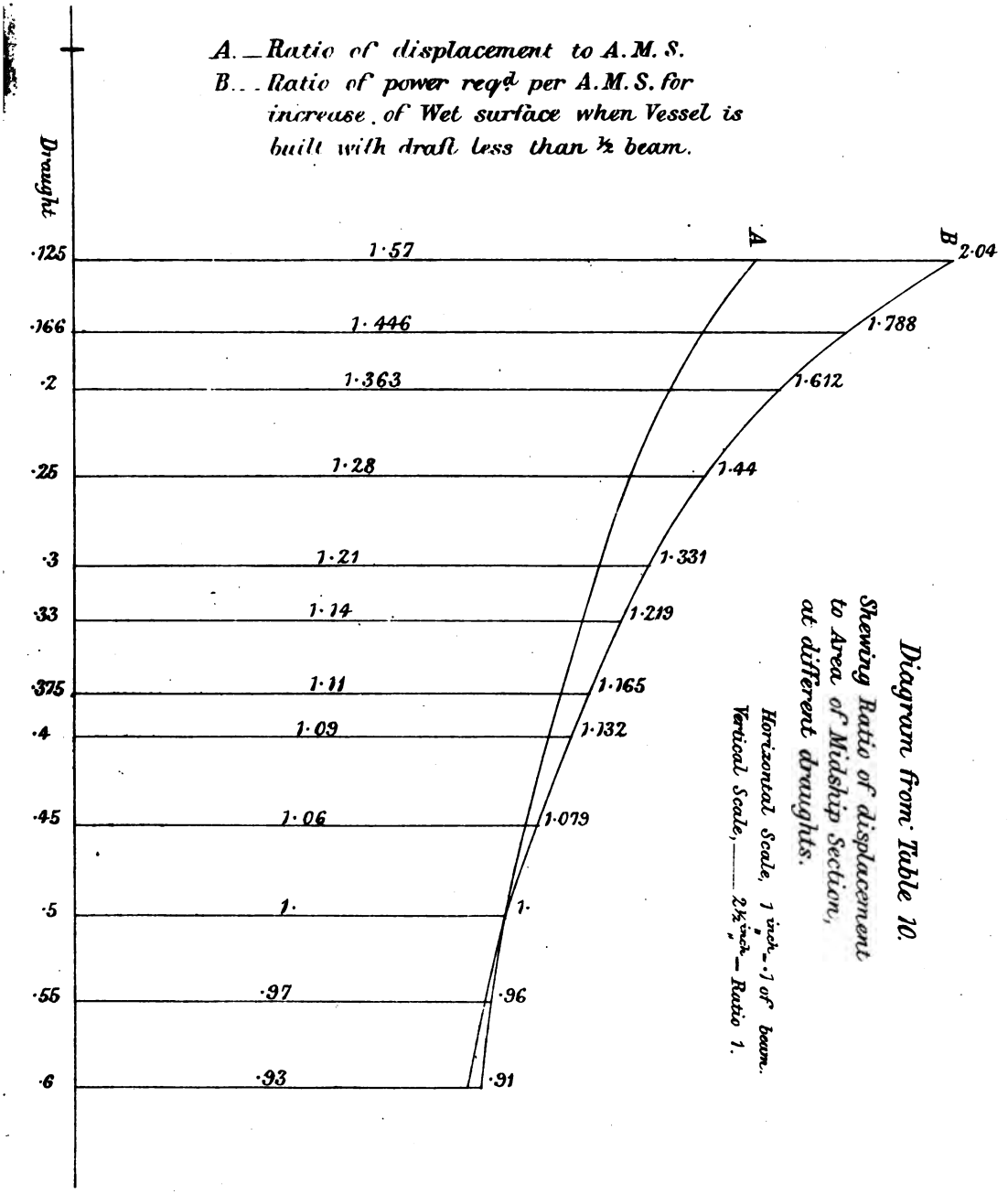


Diagram from Table 10.

Shewing Ratio of displacement to Area of Midship Section, at different draughts.

Horizontal Scale, 1 inch = 1 of beam.
Vertical Scale, 2½ inch = Ratio 1.